RESEARCHES

ON THE

SOLAR SPECTRUM,

AND THE

SPECTRA OF THE CHEMICAL ELEMENTS.

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SECOND PART.

TRANSLATED WITH THE AUTHOR'S SANCTION FROM THE TRANSACTIONS OF THE BERLIN ACADEMY FOR 1862.

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WITH TWO PLATES.

MACMILLAN AND CO.

Cambridge:

AND 23, HENRIETTA STREET, COVENT GARDEN,

London.

1863.

Cambridge:
PRINTED BY C. J. CLAY, M.A.
AT THE UNIVERSITY PRESS.

ON THE SOLAR SPECTRUM AND THE SPECTRA OF THE CHEMICAL ELEMENTS.

SECOND PART.

An accurate knowledge of the bright lines which occur in the spectrum of an incandescent gas is best obtained by a direct comparison of such lines with the fixed lines in the solar spectrum. If the Sun's rays be allowed to fall through one half of the slit on the spectrum-apparatus, whilst the light from the incandescent gas passes through the other half, the solar spectrum, with its attendant dark lines, forms a scale the delicacy and unalterable character of which is unequalled. In order to prevent the greater number of these lines from blending together and thus disappearing, on account of their extremely small breadth and slight distance from each other, it is necessary to obtain a very pure and long spectrum by using several prisms, and a telescope of high magnifying power. With such an instrument, each one of the fine dark solar lines can be as easily distinguished from the others as the marks on an ordinary divided scale, so characteristic and various are the clusters, differing in breadth, tint, and arrangement, into which these lines are grouped. The solar spectrum may, therefore, be used instead of a common scale if we can succeed in designating the several dark lines. This may be done by means of a drawing of the solar spectrum to which an arbitrary scale is attached. The drawing only needs to be so nearly correct that, when it is compared with the spectrum itself, the individual lines can thereby be recognized.

The comparison of the spectra of incandescent gases with the solar spectrum possesses, however, a value beyond that of ascertaining the exact position of these bright lines; it yields us a knowledge of the composition of the solar atmosphere.

The bright lines of certain chemical elements coincide with the dark lines of the solar spectrum, and, from a theory advanced by me, it follows that *these* elements are present in the solar atmosphere in a gaseous state.

In the first part of this work[1] I have published a drawing which I believe answers the required purpose, and in which the bright lines of many chemical elements are likewise represented. This drawing, however, includes only those portions of the solar spectrum lying between the line *D*, on the one hand, and a position a little beyond the line *F* on the other. These portions of the spectrum are interesting inasmuch as they are those in which the lines can be most accurately observed, on account of their being the brightest portions both of the solar spectrum and of the spectra of most glowing gases. Still, in the whole of the blue, yellow, and red portions of the spectrum, as examined by my apparatus, the brightness was sufficiently great to allow of a very considerable degree of accuracy in the observations. Hence, my original intention was to map the whole of that part of the spectrum lying between the lines *A* and *G*; I was afterwards obliged to restrict my observations to the portion of the spectrum published in Part I. of this work, but I proposed that my pupil, Mr K. Hofmann, should continue the investigation which I was unable to complete.

Mr Hofmann has employed exactly the same apparatus and methods which I have described in the first part of this publication; sometimes, however, in his examination of the spectrum of the electric spark, he was obliged, owing to the slight amount of light, to replace the telescope of the magnifying power 40 by another of the power 20. The results of his observations are given in Plates I.*a*, and III., arranged in the same manner as mine were arranged in Plates I. and II.; Plate I.*a* represents the spectrum from *A* to *D*; Plate III. begins at the point where Plate II. ends, and extends as far as *G*. In addition to the elements whose spectra I had already examined, Mr Hofmann has investigated the spectra of the following metals;—

[1] *Researches on the Solar Spectrum, &c.* Part I. Macmillan and Co. Cambridge.

potassium, rubidium, lithium, cerium, lanthanum, didymium, platinum, palladium, and an alloy of iridium and ruthenium. The lines belonging to these metals, which appear on Plates I.*a* and II., are catalogued in the Appendix; and in this, as well as in the drawing, three degrees of brightness are represented, the number 3 denoting the greatest, and No. 1 the least degree of brightness. As in the former drawings, only the more striking of the lines are here reproduced, a complete delineation of the lines not being attempted.

The potassium spectrum could not be obtained in the same way as the spectra of the other alkaline metals. If the chloride, borate, or sulphate of potassium, is brought upon the electrodes, no new lines appeared; if the electrodes themselves were made of metallic potassium, the potassium lines represented on Plate I.*a* were seen, but they were so faint that only two prisms could be used in order to find their position in the solar spectrum, and the intensity of the sunlight had to be diminished by interposition of very dark glasses. The line *K.a* is better seen when a non-luminous gas-flame is employed than when an electric spark is used. In our first memoir on spectral analysis, Bunsen and I represented this line in our drawings as a single line coincident with Fraunhofer's line *A*. This indeed always appears to be the case when this spectrum is examined by the slight magnifying power which is most convenient for the object we then had in view, but, when observed by the power used in the preparation of these drawings, the red potassium line turns out to be a double line each of whose parts is less refrangible than *A*. It has already been shewn by Debray, Grandeau and Roscoe, that this is a double line; and Morren has observed that it is less refrangible than *A*[1]. Near *B* there is another double line in the potassium spectrum, but neither of these lines is coincident with *B*. Concerning the spectra of lanthanum and didymium I may remark that the lanthanum salt used for the experiments contained didymium, and the didymium salt contained lanthanum; hence the spectra appear to be almost identical. A portion of the two salts was brought on to the two pair of electrodes, and a

[1] *Chemical News*, Dec. 7, 1861, p. 303.

simultaneous spark passed through each pair; the light from one spark passed through the one half of the slit, the light from the other spark through the other half. The direct comparison of the two spectra, which was thus rendered possible, shewed that certain lines were brighter in the one spectrum, and other lines brighter in the other spectrum. In many cases the difference in brightness was so great that the origin of the lines might be distinguished with certainty, whilst in other cases such a discrimination was not possible; these last are marked (*La Di*) in the Table.

These additional observations have not yielded any new information respecting the constituents of the solar atmosphere, they have, however, confirmed the results of the previous examination.

A large number of iron lines occur in the yellow and blue portions of the spectrum, and all of these are coincident with well defined Fraunhofer's lines; the same remark applies to all the calcium lines. The probability that nickel is visible in the solar atmosphere is greatly increased by the numerous coincidences, which Mr Hofmann has noticed, between the bright nickel lines, and the dark lines of the solar spectrum. The question as to whether cobalt is visible, has not received any further elucidation, as many cobalt lines between *C* and *D* and between *F* and *G* are coincident with Fraunhofer's lines, whilst others, equally bright, have no coincident solar line. New coincidences seen in the spectra of barium, copper and zinc with dark solar lines, confirm the presence of these elements in the sun's atmosphere. Mr Hofmann has also observed a few coincidences in the spectra of strontium and cadmium, but their number is too small to warrant the conclusion that these metals are present. The other chemical elements which were examined did not appear to be visible in the solar atmosphere. This is also the case with potassium. There are, indeed, fine Fraunhofer's lines situated close to the red potassium lines, but the brightness of the latter was too faint to render it possible to determine whether they coincided or not with any dark solar lines.

Mr Hofmann has likewise paid some attention to the examination of the atmospheric lines discovered by Sir David Brewster. The locality in which the observations had to be made was, however, not well adapted for the purpose of these observations, as the sun-light disappeared when the sun approached the horizon. Still in September last, at four to five o'clock, P.M. Mr Hofmann observed a large number of dark lines, which were far more intense then than they had been at noon, and therefore arose, either wholly or partly, from absorption in the Earth's atmosphere. These lines are catalogued in the Appendix. It is of interest to notice that amongst these the lines 972.1, 977.4, 977.7 and 982.0 occur, which are coincident with remarkable bright lines appearing in the spectrum of the electric spark when it is allowed to pass through the air.

APPENDIX.

TABLE I. *a*. STRIP 1.

381.7	1*c*	463.3	2*a*	497.5	2*a*	554.6	2*b*	591.5	4*b*	
384.1	2*c*	466.0	1*b*	498.4	4*c*	557.0	1*a*	591.9	4*b*	
385.9	2*d*	466.5	2*c*	499.0	5*b*	557.7	2*b*	592.3	3*b*	
387.5	3*d*	467.0	1*b*	499.9	5*d*	558.1	1*b*	592.7	6*c*	
388.9	4*d*	468.1	2*c*	500.8	3*d*	559.7	1*c*	593.1	4*g*	
390.4	4*e*	470.0	2*b*	501.8	2*c*	561.5	1*b*	595.0	1*a*	
392.1	5*c*	470.5	3*c*	502.0	5*b*	562.5	3*b*	596.6	1*a*	
393.6	6*c*	470.9	2*b*	502.6	5*c*	563.0	2*c*	597.4	1*b*	
395.0	6*c*	472.4	2*c*	503.8	6*d*	564.1	4*c*	601.2	1*a*	
396.2	5*e*	472.7	3*c*	504.3	5*b*	565.0	2*c*	601.8	1*b*	
397.4	4*e*	473.8	4*d*	505.1	6*c*	566.0	2*c*	602.8	1*a*	
398.4	4*d*		1	506.2	2*b*	566.9	2*b*	606.0	1*b*	
399.2	4*d*	474.7	3*b*	506.4	5*b*	567.4	3*b*	608.3	1*a*	
399.8	4*d*	from 475.7	2	506.6	2*b*	568.6	2*b*	612.4	1*b*	
400.4	3*d*	476.4	1*b*	507.4	5*c*		1	613.4	1*a*	
401.9	4*c*		2	508.2	3*b*	569.2	2*b*	623.4	1*b*	
402.4	3	477.0	5*b*	509.1	3*b*		1	626,1	1*b*	
402.8	4		2	509.9	2*b*	570.0	3*c*	631.4	1*b*	
403.2	5	477.8	4*b*	510.9	1*a*	570.6	2*b*	638.4	1*b*	
405.0	6	479.1	2*c*	512.9	2*b*	572.2	3*b*	639.8	1*b*	
405.6	5		1	513.6	3*b*	572.9	1*b*	641.0	2*b*	*Ca.*
406.2	4	480.1	6*c*	517.1	2*b*	573.6	3*c*	645.3	1*b*	
	3	480.4	4*d*	519.3	2*b*	574.4	1*b*	648.1	1*b*	
406.8	5*c*	481.2	4*c*	521.6	1*b*	575.1	2*d*	654.3	2*b*	
408.5	1*d*	482.1	2*d*	529.4	1*b*	576.6	2*d*	659.3	2*a*	
423.7	2*b*	483.3	4*d*	530.4	1*c*	578.1	3*d*	665.7	2*a*	
426.6	2*b*	484.1	2*d*	532.8	1*b*	579.6	3*d*	669.5	2*b*	
433.8	2*c*	485.1	3*d*	536.9	2*b*	581.1	3*e*	678.6	1*b*	
437.0	2*b*	486.2	6*c*	537.3	1*b*	582.5	3*e*	681.4	1*a*	
442.8	2*d*	486.8	2*c*	540.6	3*b*	583.8	4*c*	682.8	1*b*	
444.6	2*c*	from 488.2	1	541.1	2*c*	585.0	4*f*	683.1	2*a*	
445.8	2*b*	488.8	5*a*	542.0	1*a*	586.2	4*c*	685.3	1*b*	
446.1	2*b*	489.6	6*c*	543.6	4*b*	587.0	3*c*	689.8	2*b*	
447.0	2*a*	491.2	3*c*	544.6	3*d*	587.9	2*b*	690.9	1*a*	
448.4	1*b*	491.5	5*b*	547.0	4*c*	589.0	3*b*	692.1	2*a*	
452.6	2*c*	491.9	4*c*	547.9	2*b*	589.4	3*b*	from 693.4	1	
453.0	1*b*	493.1	2*c*	549.6	3*e*	589.9	3*b*	694.1	6*e*	*Air.*
454.4	1*b*	494.1	3*b*	551.2	3*c*	590.3	3*b*	to 694.1	1	
460.0	1*c*	495.4	1*e*	552.5	3*c*	590.7	3*b*	698.1	2*a*	
461.0	1*b*	495.7	2*b*	553.8	1*c*	591.1	3*b*	700.0	2*a*	
462.2	2*b*	497.2	1*b*	554.0	3*b*					

TABLE I. *a*. STRIP 2.

	690.9	1a		774.8	2b		849.7	3c	Fe
	692.1	2a		778.3	1b	(Ru, Ir)	851.2	1a	
from	693.4	1		779.5	1b		851.8	1a	
	694.1	6c	Air	781.9	3b		855.0	2a	
to	694.8	1		783.1	4b		856.8	2a	
	698.1	2a		783.8	3b		857.5	2a	
	700.0	2a		786.8	1a		858.3	2a	
	701.1	2b		788.9	3b		859.7	3a	
	702.1	2a		791.0	1d		860.2	3d	Ca
	702.6	1b		791.4	3b		861.6	2a	
	705.5	2a		792.9	2d		862.2	1a	
	705.9	2a		794.5	1d		863.2	2c	
	707.5	1b		798.1	3a		863.9	5b	Ca
	708.6	2b		798.5	4a	Fe	864.4	1d	
	710.5	2c		799.8	2b		866.2	2b	
	711.4	3c		800.3	2b		867.1	2b	
	712.0	2b		801.2	1a		867.6	1a	
	713.2	1b		801.5	1a		869.2	2b	
	714.4	1c		802.7	1b		870.9	1b	
	717.8	2b	Ca	803.5	2a		871.4	2b	
from	718.7	2	Ba	805.8	1b		872.5	1b	
	719.6	3a		807.4	2b		874.0	1b	
	720.1	2c	Ca	808.2	2c		874.3	4b	Ba
	721.1	2b	Fe	808.7	1c		876.5	4a	
	723.7	2c		809.5	3b	Au	877.0	4c	Fe
	724.2	1b		809.9	2d		879.8	1b	
	725.1	1b	Air	812.7	1a		880.9	1a	
	726.7	3c		813.1	2a		881.6	2a	
	727.8	1c		815.0	4b		882.6	1a	
	728.0	2a		816.8	2b		883.2	1b	
	729.0	2b	Ca	818.0	3c		884.9	4b	Ca, Co
	731.7	5b	Ca	819.0	4b		887.7	2a	Ni
	734.0	1d		820.1	4b		890.2	1b	Ba
	736.9	3b	Ca	820.9	4b		891.7	2a	Ni
	740.9	5b	Ca, Cd	823.5	1a		894.9	2c	Ca, Li
	743.7	2b		824.0	4b		896.1	1a	
	744.3	4b		824.9	1d		896.7	1b	
	748.1	4b		826.4	2a		898.9	1a	
	748.7	3b		827.6	1a		899.1	1a	
	750.1	1a		828.0	2a		900.2	1a	
	751.0	1b		830.2	3b		901.4	1a	
	752.3	4b		831.0	4c	Fe	901.6	1a	
	753.8	3b	Sr	831.7	1b		902.4	1a	
	756.9	5b	Fe	836.5	2b		903.1	1a	
	759.3	3b		838.2	1b		903.6	1a	
	764.2	1a		838.6	2b		904.6	1a	
	771.8	1a	Zn	839.2	2b		906.1	2c	
	773.4	2b		845.7	2b		912.1	3b	Fe

916.3	2*b*		963.7	1*c*		986.7	2*c*	
923.0	2*b*		964.4	1*c*		987.4	1*b*	
929.5	2*b*		968.7	2*a*		988.9	2*a*	
931.3	4*b*	*Fe*	969.0	2*a*		989.2	2*a*	
932.5	4*b*		969.6	3*a*		989.6	2*a*	
933.3	4*c*		970.5	1*b*		990.8	2*a*	
935.1	4*b*		971.5	2*c*		991.2	1*a*	
936.7	4*b*		972.1	1*b*		991.9	3*b*	*Fe*
937.4	1*b*		973.1	3*a*		992.4	1*a*	
940.1	3*b*		973.5	3*a*		993.9	1*b*	
940.4	2*b*		974.3	2*a*		994.3	1*b*	
943.4	3*b*		975.0	2*a*		995.0	1*a*	
946.6	3*b*		976.8	3*a*		997.2	2*b*	
947.0	1*a*		977.4	2*a*		998.1	1*a*	
949.4	1*b*		977.7	2*a*		998.9	1*a*	
949.8	1*b*		979.1	1*b*		999.2	1*a*	
951.7	1*c*		980.8	1*a*		1000.0	1*a*	
952.9	3*b*		981.2	3*b*		1000.4	1*a*	
954.3	3*b*		982.0	1*a*		1001.4	1*a*	
954.8	3*b*		982.3	2*a*		1002.8	6*b*	*Na*
958.8	3*b*		983.0	3*c*		1005.0	2*b*	*Ni*
959.6	3*b*		984.5	1*c*		1006.8	6*b*	*Na*
961.9	1*a*		986.3	1*a*				

TABLE III. STRIP 1.

	2240.0	3*b*	*Zn*
	2241.4	2*b*	
	2245.1	3*b*	
	2246.2	1*b*	
	2248.2	3*c*	
(	2249.7	6*b*	*Ni*
(	2250.0	3*d*	
	2255.4	4*b*	
	2256.2	2*b*	
	2257.1	4*d*	
	2257.6	2*b*	
	2258.5	2*c*	
	2259.4	4*c*	
	2261.4	1*b*	
	2262.1	2*a*	
	2263.4	2*a*	
	2264.3	6*d*	
	2266.2	2*a*	
	2266.6	2*a*	
	2268.0	3*a*	
	2269.1	3*a*	
	2269.9	3*a*	
	2270.2	3*a*	
	2274.2	1*d*	
	2278.4	4*c*	
	2279.8	2*a*	
	2280.7	2*a*	
	2282.0	1*a*	
	2282.3	1*b*	
	2283.6	2*a*	
	2284.9	2*b*	
	2286.1	2*b*	
	2288.1	2*a*	
from (	2289.1	1	
(	2289.9	2*b*	
	2290.4	1*b*	
	2291.8	2*g*	*Zn*
(	2293.1	2*a*	
(		1	
(	2293.6	3*b*	
	2294.5	2*b*	*Cd*
	2301.7	4*c*	
	2302.9	3*b*	
	2305.3	3*d*	
	2306.8	4*c*	
	2307.8	1*b*	
	2308.2	5*b*	
(	2309.0	5*c*	
to (	2310.4	1	
	2310.9	2*c*	
	2312.5	3*b*	
	2313.7	3*b*	
	2314.3	3*b*	
	2316.0	2*b*	
	2316.6	1*b*	
	2322.0	2*b*	
	2323.0	2*b*	
	2325.3	6*d*	
	2328.3	5*b*	
	2329.5	5*b*	*Cu*
(	2332.8	2*b*	
(	2333.0	5*b*	
	2334.1	2*d*	*Ni*
	2335.0	5*b*	
	2336.2	2*d*	
	2336.8	5*b*	
	2339.9	4*b*	
	2342.5	1*d*	
from (	2343.7	1	
(	2345.1	2*d*	
	2346.7	4*b*	
	2347.3	4*b*	
	2349.4	1*b*	
	2349.9	2*b*	
	2351.4	1*c*	
	2352.2	2*b*	
	2354.1	6*c*	
	2357.4	5*a*	
	2358.4	5*b*	
	2361.0	1*d*	
	2362.2	1*c*	
	2362.6	4*b*	
	2364.0	4*b*	
	2365.9	2*b*	
	2366.8	1*b*	
	2367.7	2*b*	
	2369.7	2*b*	
(	2371.4	2*b*	
(	2371.6	4*b*	
	2372.4	4*b*	
	2374.2	3*b*	
	2375.0	2*b*	
	2375.6	4*b*	
	2376.1	1*b*	
	2379.0	6*c*	
	2381.6	6*c*	
	2386.1	3*b*	
	2386.6	2*a*	
	2388.7	2*c*	
	2389.7	2*c*	
	2390.7	3*a*	
	2391.2	1*b*	
	2393.1	5*b*	
	2394.4	4*a*	
(	2395.8	1*f*	
(	2396.1	3*b*	
(	2396.7	2*a*	
(		1	
(	2397.4	2*a*	
	2399.6	3*a*	
	2399.9	3*a*	
	2402.2	3*b*	
	2403.2	3*b*	
	2404.9	2*b*	
	2406.2	2*b*	
	2406.6	6*c*	
	2407.2	1*b*	
	2408.2	4*b*	
	2409.0	1*b*	
	2410.2	4*b*	
	2412.8	3*b*	
	2414.7	2*b*	
(	2416.0	3*d*	
(	2416.3	5*b*	
	2418.0	3*b*	
	2419.3	5*b*	
	2420.6	2*b*	
	2422.3	6*d*	*Co*
	2423.8	3*c*	
	2424.4	4*b*	
	2426.5	4*b*	
	2428.4	1*a*	
	2429.5	3*b*	
	2431.9	2*b*	
	2432.4	1*b*	
(	2435.3	2*b*	
(	2435.5	5*c*	
(	2435.7	2*b*	
(	2436.5	5*a*	
	2438.5	1*a*	
	2439.4	2*b*	
	2440.0	1*a*	
	2441.8	2*a*	

2442.4	1*a*		2480.1	2*a*		2522.3	1*a*	
2443.9	5*a*		2481.1	1*a*		2525.0	2*a*	
2444.2	5*a*		2482.1	1*a*		2525.4	1*b*	
2445.3	1*c*		2482.4	1*c*		2527.0	4*a*	
2446.6	5*b*		2486.6	5*b*		2532.0	2*b*	
2452.1	2*c*		2487.0	5*b*		2535.5	2*b*	
2454.1	4*b*		2488.2	4*b*		2535.9	2*b*	
2457.5	4*b*		2489.4	5*d*		2536.6	1*b*	
2457.9	4*b*		2490.5	5*a*		2537.1	5*c*	
2458.6	3*a*		2490.8	3*d*		2538.0	1*b*	
2459.5	2*b*		2493.0	3*a*		2538.3	2*a*	
2460.4	1*c*		2493.6	5*a*	*Co*	2540.5	2*g*	*Pt*
2461.2	6*b*	*Ba*	2493.9	3*f*		2543.5	4*c*	
2463.4	4*b*		2495.8	5*b*		2544.5	2*d*	
2466.0	3*a*		2497.2	6*d*		2545.4	1*c*	
2467.3	3*c*		2499.0	3*b*		2547.2	6*c*	
2467.6	5*c*		2499.8	3*b*		2547.7	2*b*	
2467.9	3*c*		2500.3	4*c*		2548.4	1*c*	
2468.7	3*a*		2502.2	4*c*	*Ba*	2549.7	1*b*	
2470.1	4*a*		2502.4	1*b*		2550.1	1*b*	
2471.2	2*b*		2505.6	4*d*		2551.2	1*b*	
2471.4	4*a*		2509.4	2*d*		2551.4	3*a*	
2472.9	4*a*		2512.1	1*c*		2552.4	3*a*	
2473.8	2*c*		2512.5	2*a*		2552.6	1*b*	
2474.6	4*b*		2513.2	2*b*		2553.6	3*a*	
2475.5	1*c*		2513.5	1*b*		2554.0	3*a*	
2477.4	2*a*		2517.0	3*b*		2554.9	3*a*	
2477.8	2*a*		2518.2	2*c*		2555.1	2*c*	
2478.7	2*a*		2518.4	3*a*		2556.3	2*c*	
2479.7	2*a*		2520.9	3*a*		2559.9	3*b*	

TABLE III. STRIP 2.

Wave-length	Intensity	Remarks
2550.1	1*b*	
(2551.2	1*b*	
2551.4)	3*a*	
(2552.4	3*a*	
2552.6)	1*b*	
2553.6	3*a*	
2554.0	3*a*	
(2554.9	3*a*	
2555.1)	2*c*	
2556.3	2*c*	
2559.9	3*b*	
2562.1	4*b*	
2564.0	3*b*	
2565.0	6*c*	
2565.9	2*b*	
2566.3	3*d*	
2567.8	3*b*	
2568.4	2*b*	
2574.4	5*c*	
2579.3	3*d*	
2581.0	1*a*	
2581.5	1*a*	
2582.0	2*a*	
2582.4	2*a*	
2582.8	1*a*	
2584.0	3*c*	
2585.4	5*b*	
2587.9	3*a*	
2588.5	5*b*	
2589.7	1*b*	
2591.3	4*a*	
2591.7	2*c*	
2593.0	1*c*	
(2594.9	2*b*	
	1	
2595.4)	4*a*	
(2595.9	4*a*	
	1	
2596.4)	2*c*	
2597.7	3*b*	
2598.5	1*b*	
(2599.4	3*c*	
2599.7)	5*b*	
2600.6	2*a*	
2601.0	2*c*	
2602.1	4*b*	
2602.9	1*a*	
2603.6	2*b*	
2604.0	1*a*	
2604.8	4*b*	
(2605.8	3*b*	} *Ca*
	2	
2606.6)	5*c*	
2607.1	3*c*	
2608.2	1*c*	
2608.6	1*b*	
2608.9	1*a*	
2610.2	1*a*	
2612.3	3*b*	
2613.6	2*c*	
2614.1	3*c*	
2616.5	2*b*	
2619.1	5*b*	
2619.9	3*a*	
2620.3	3*a*	
2622.3	1*b*	
2624.1	1*b*	
2625.2	5*a*	
2625.9	4*a*	
2626.3	2*a*	
2627.0	5*b*	
2627.9	2*a*	
2628.9	1*c*	
2629.7	1*b*	
2630.5	1*a*	
2633.6	2*c*	
2634.4	1*d*	
2635.5	3*b*	
2636.4	2*c*	
2637.4	4*b*	
(2638.5	4*c*	} *Ca*
2638.8)	5*a*	
2639.6	1*c*	
2640.6	2*c*	
2641.6	3*c*	
2642.5	2*a*	
2643.2	1*a*	
2643.5	1*a*	
2645.6	4*b*	
2646.2	2*g*	(*La*, *Di*)
(2650.5	5*b*	
2650.7)	3*c*	
(2652.9	1*d*	} *Ca*
2653.2)	5*b*	
from (2656.7	1	
2657.9)	3*b*	
2658.6	1*b*	
2664.9	3*a*	
2665.9	3*b*	
2666.7	1*b*	
2667.6	3*a*	
2668.0	1*b*	
2669.4	3*b*	
2670.0	6*c*	*Fe*
2673.8	1*a*	
2674.5	2*a*	
2675.6	2*c*	
2676.5	2*a*	
2677.2	1*a*	
2678.4	1*a*	
2679.0	2*a*	
(2680.0	5*b*	
2680.2)	3*b*	
2681.2	5*a*	
2683.1	4*b*	
(2686.0	3*c*	
2686.4	6*f*	*Fe*
2686.8)	3*c*	
2688.4	2*c*	
(2690.8	5*b*	
2691.1)	3*c*	
2692.3	3*c*	
2693.5	4*c*	
from 2695.2	} 1	
to 2696.8		
2698.2	1*f*	
from (2699.8	1	
2700.7)	2*a*	
(2702.1	3*b*	
2702.3	4*a*	
2702.5)	3*b*	
2703.5	3*a*	
from 2703.8	} 1	
to 2704.9		
(2707.4	1*f*	
2707.7)	3*a*	
2708.9	4*b*	
2709.6	2*b*	
(2710.6	3*a*	
2710.9)	1*g*	
2711.9	1*a*	

2712.8	2a	
2713.3	3a	
2714.3	2a	
2715.2	2b	
2716.1	1d	
2718.5	3g	
2719.0	4c	
	1	
2720.2		
	2	
2720.8		Fc
	6	
2721.6		
	3	
2722.8		
2725.5	2d	
2725.8	3a	
2726.8	2a	
2728.0	4b	
2728.4	1b	
2729.8	2c	
2730.7	1b	
2731.6	3c	
2732.4	1c	
2733.7	5b	
2734.1	3b	
	1	
2735.7	3b	
2736.5	3b	
2736.9	3b	
2737.4	1a	
2737.8	2a	
2739.2	2c	
2739.9	1b	
2741.3	3d	
2741.7	3b	
2743.8	1f	
2744.1	4c	
2744.3	1d	
2746.8		
	1	
2747.2		
2747.6	3a	
2748.0	4c	
2749.8	3c	
2750.6	3a	
2754.5	2c	
2755.4	1b	
2755.8	2b	
2756.5	1c	
2757.2	1c	
2759.4	1a	
2760.1	2a	
2760.6	2d	
2762.0	4e	
2763.8	3f	
2767.2	1d	
2768.2	2a	
2768.5	1a	
2770.0	2b	
2770.8	2b	
2774.0	5c	
2775.4	4c	
2775.7	6c	
2776.0	4c	
2777.3	3a	
	2	
2777.8		
	1	
2778.5		
2781.2	2b	
2782.2	1b	
2782.9	3b	
2783.9	1b	
2784.8	1c	
2785.1	2c	
2788.8	1b	
2789.1	3c	
2790.5	1c	
2791.1	3b	
2793.0		
	1	
2794.0		
	2	
2795.7		
	6	
2796.7		
	2	
2797.6	3b	
	2	
2798.0	3b	
	1	
2798.9	2c	
	1	
2799.5	2c	
	1	
2800.1	3b	
	1	
2800.7	3b	
	1	
2801.4	4d	
2804.5	1b	
2805.4	1b	
2806.9	1c	
2807.2	2a	
2808.6	1b	
2808.8	2a	
2809.0	1b	
2810.8	2b	
2811.7	2a	
2812.0	2a	
2812.5	2a	
2812.8	1c	
2814.1	1b	
2817.7	3c	
2819.2	3b	
2819.6	2b	
2820.6		
	2	
2821.0		
	3	
2821.6		
	6	Fc
2822.3		
	3	
2823.4	4c	
2824.2	3a	
	2	
2825.0	4c	
	3	
2825.9	4b	
	3	
2826.5	4e	
2828.9	3b	
2830.7	3g	
2834.2	5c	Ca
2837.7	1g	
2841.4	5b	
2841.7	4c	
2843.0	3d	
2843.3	4a	
2844.0	3b	
2845.3	4f	
	2	
2846.1	3c	
	2	
2846.9	4c	
	1	
2847.7	4a	
	2	
2848.0	4a	
	2	
2848.4	3b	
	2	
2848.9	3b	
	2	
2849.3	3b	
	2	
2849.8	3b	
	2	
2850.2	3b	
	2	
2850.7	3b	

	2	
2851.1	3*b*	
	2	
2851.6	3*b*	
	2	
2852.0	4*a*	
	2	
2852.3	4*a*	
	1	
2853.1	3	
2853.6	4	
2854.1	6	*Fe*
2854.7	4	*Ca*
2855.2	3	
2855.7		
2856.9	4*d*	
from 2857.9	3	*Sr*
2858.5	4*a*	*Sr*
	2	*Sr*
2858.9	3	*Sr*

2859.4	1	
2860.2	2	
2860.9		
	1	
2861.7	4*b*	
2861.9	3*b*	
	1	
2863.1	3*b*	
2863.6		
	4	
2864.2	5*b*	
	2	
2864.7	4*b*	*Ca*
	2	
2865.3	4*c*	
	1	
2866.3	5*b*	
	3	

2867.1		
	2	
2868.1	4*c*	
	3	
2869.7	5*c*	*Ca*
	4	
2871.2		
2872.2	4*d*	
	1	
2873.4	2*b*	
	1	
2873.9	2*b*	
	1	
2874.3	3*b*	
	1	
2874.7	2*b*	
	1	
2875.2	4*c*	

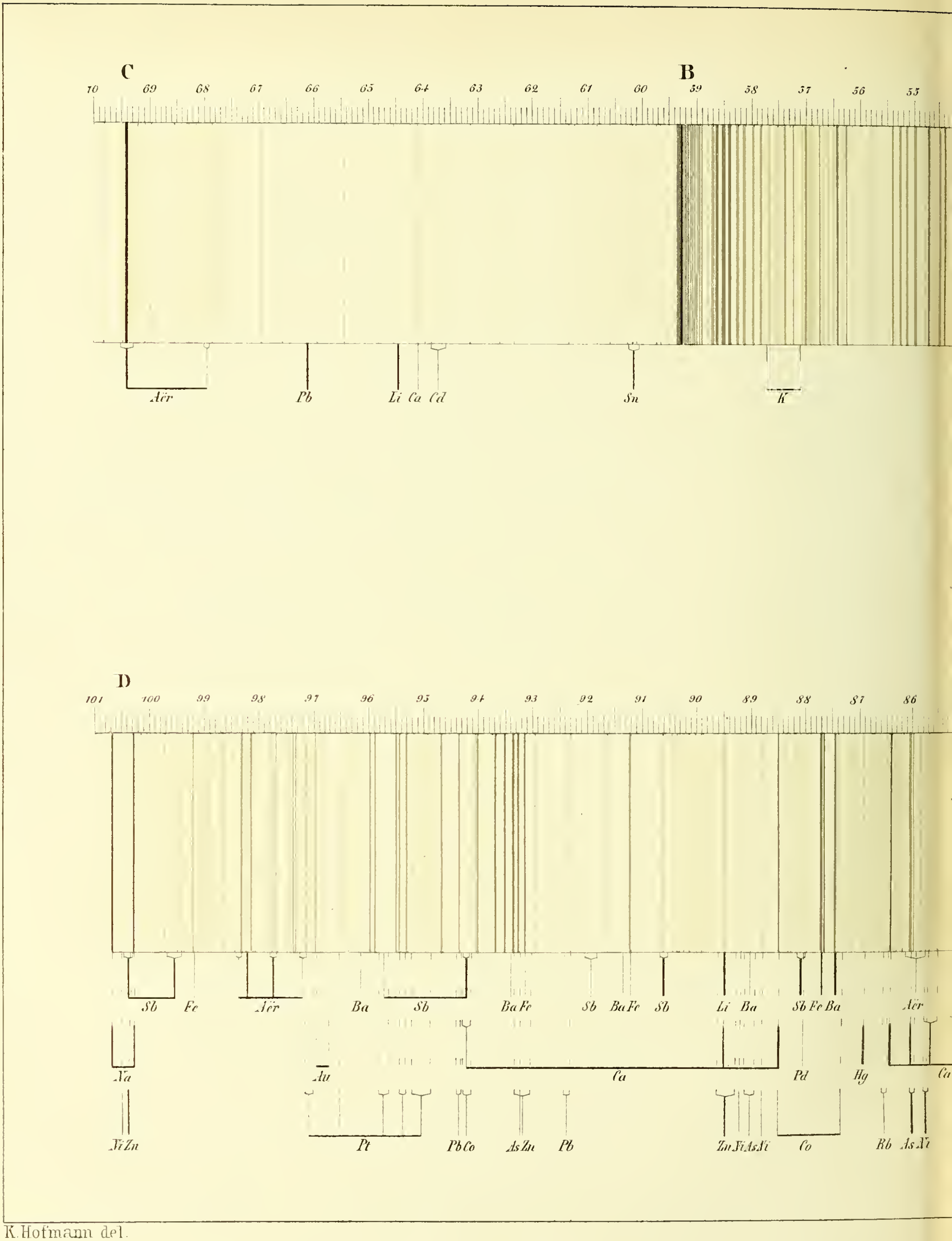
Lines represented on Tables I. and II.

(The lines marked with an asterisk appear to coincide with dark lines in the Solar Spectrum.)

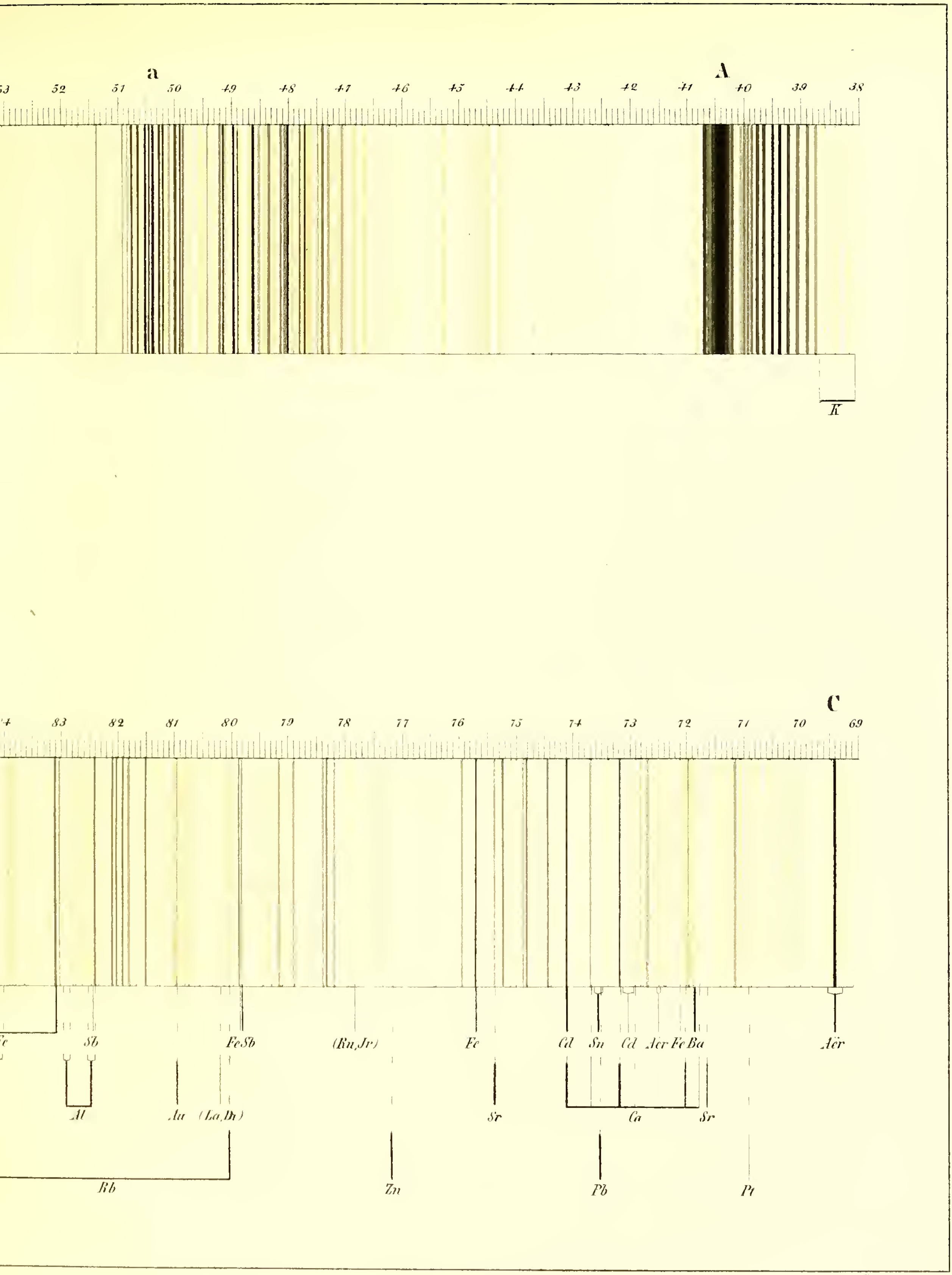
	Ce	
	1190.1	1
	1249.9	1
	1256.7	1
	1329.1	2
	1332.4	2
	1336.2	1
	1385.0	2
	1401.7	2
	*1438.9	3
	1460.9	1
	1517.9	3
from	1571.0	1
to	1572.4	
	1573.0	2
	1623.1	1
from	1629.2	2
to	1630.4	
	1683.1	1
	1725.5	1
	*1777.5	2
from	1782.4	1
to	1784.5	
	1938.8	2
	2052.3	1
	2221.5	1
	Di	
	1225.0	2
	1230.0	1
from	1364.5	1
to	1365.2	
	1431.9	1
	1471.1	1
from	1518.6	1
*to	1519.4	
	1536.0	1
	1541.4	1
	1548.9	2
	*1567.5	1
	1709.2	2
	La	
from	1411.6	2
*to	1412.8	
	1416.8	2
	1451.0	1
	1606.8	2
	1627.9	2
	1634.8	2
	2136.8	1
	(*La*, *Di*)	
	1025.0	1
	1064.5	1
	1066.1	1
	1071.1	1
	1075.6	1
	1077.0	1
	1092.1	2
	*1302.0	1
	*1303.4	2
	1317.6	1
	1345.4	1
from	1486.8	2
*to	1489.2	
	*1622.3	1
	*1623.3	1
	1716.6	2
	1728.8	2
from	1894.5	2
*to	1895.2	
	1903.0	1
	1940.2	1
from	1988.6	1
to	1989.5	
	2003.8	2
	2004.7	2
	2031.0	2
	2081.0	2
	2121.4	1
	2208.2	2
	2214.5	2
	2217.8	2
	Pd	
	1114.7	1
	*1146.2	2
	1164.9	2
	1185.6	1
	1264.6	2
	1269.0	2
	1279.1	1
from	1400.0	2
*to	1400.7	
	1430.1	1
	1447.0	1
	1477.0	1
	1495.2	3
	1540.0	1
from	1566.5	2
to	1567.1	
	1601.4	1
from	1660.0	3
to	1660.7	
	1732.9	2
	1801.9	1
	2062.0	2
	2123.6	2
	2162.0	2
	Pt	
	1325.7	1
from	1488.2	3
to	1489.0	
	1576.8	1
from	1806.1	2
*to	1806.9	
	2057.0	1
	(*Ru*, *Ir*)	
	1348.3	2
	*1489.9	1

Atmospheric Lines.

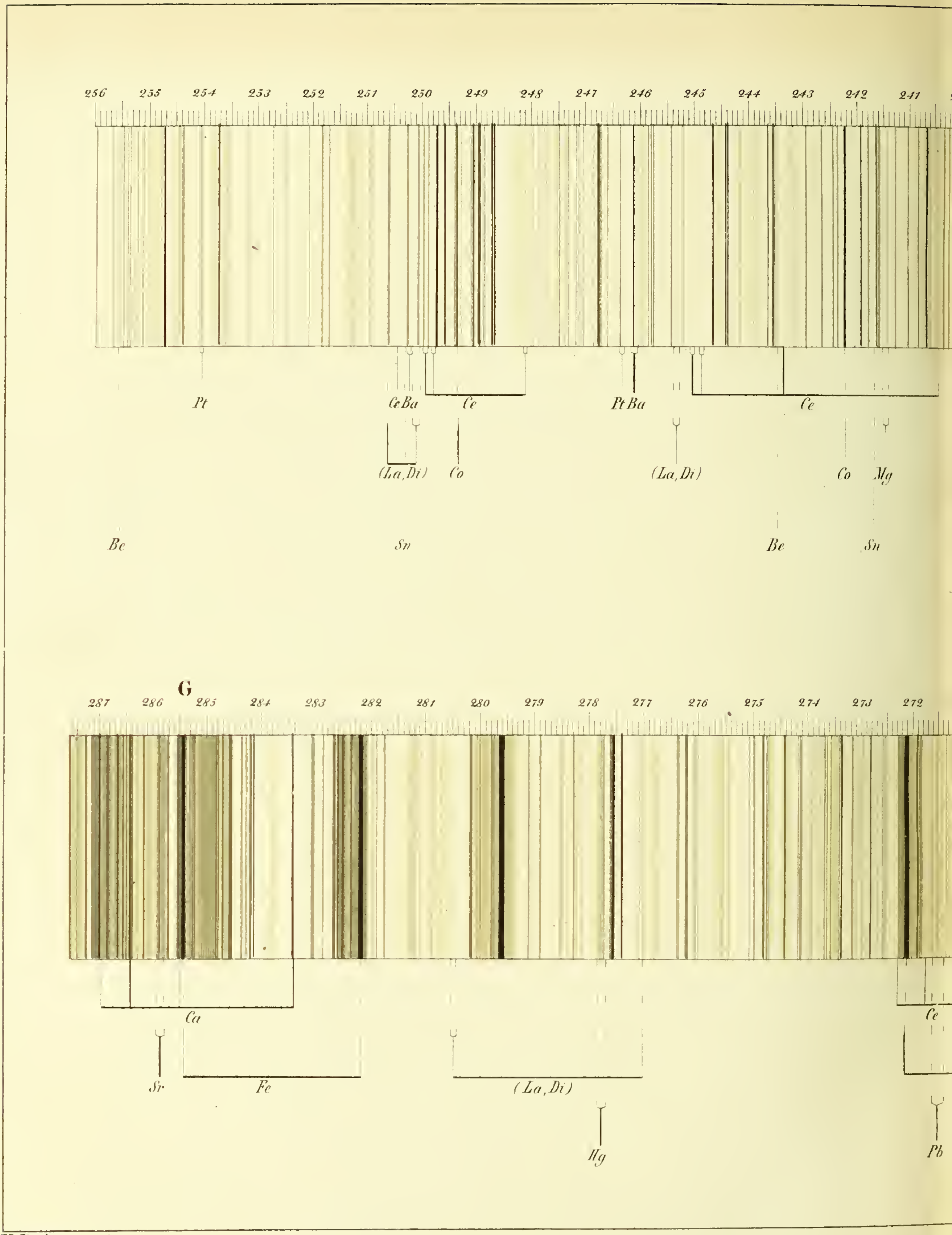
711.4	954.2	964.4	970.5	976.1	988.9	998.1	1008.3	1015.1
948.0	958.8	965.7	972.1	977.4	989.2	999.2	1009.2	1016.4
949.4	959.6	968.7	974.3	977.7	989.6	1000.0	1010.5	1017.7
949.8	961.9	969.0	975.0	982.0	993.1	1001.4	1013.9	1018.2
951.7	963.7	969.6	975.7	982.3	993.4	1005.8		



K. Hofmann del.

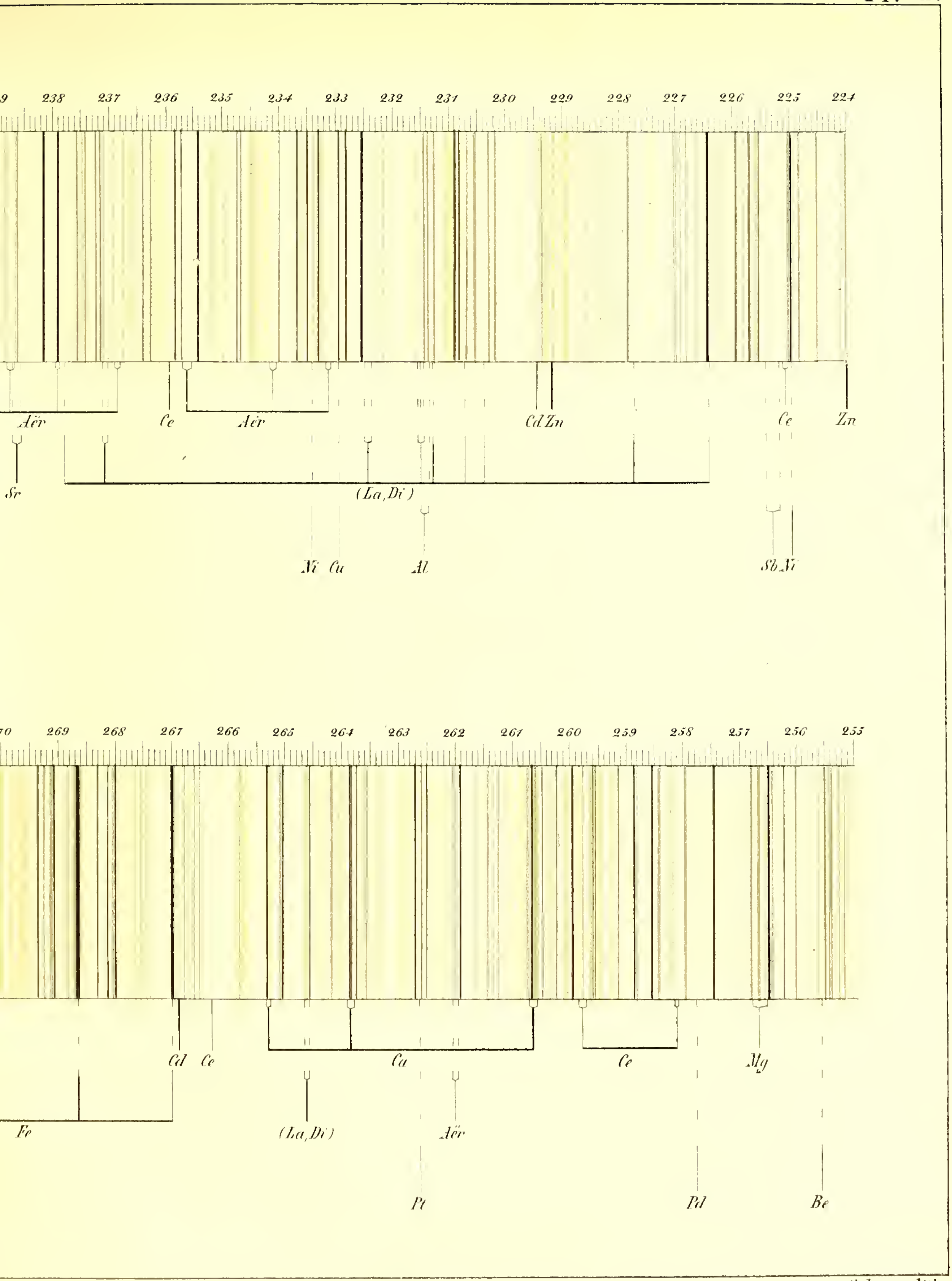

a
A
53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38
K
C
84 83 82 81 80 79 78 77 76 75 74 73 72 71 70 69
Fe Sb FeSb (Ru,Jr) Fe Cd Sn Cd Aër Fe Ba Aër
Al Au (La,Di) Sr Ca Sr
Rb Zn Pb Pt

C.Laue lith.



K. Hofmann del.

Pl. III.



C. Laue lith